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(54) METHOD OF ACTUATING A TEST FUNCTION OF AN ELECTRICAL SWITCHING APPARATUS AT A PANEL AND ELECTRICAL SWITCHING APPARATUS EMPLOYING THE SAME

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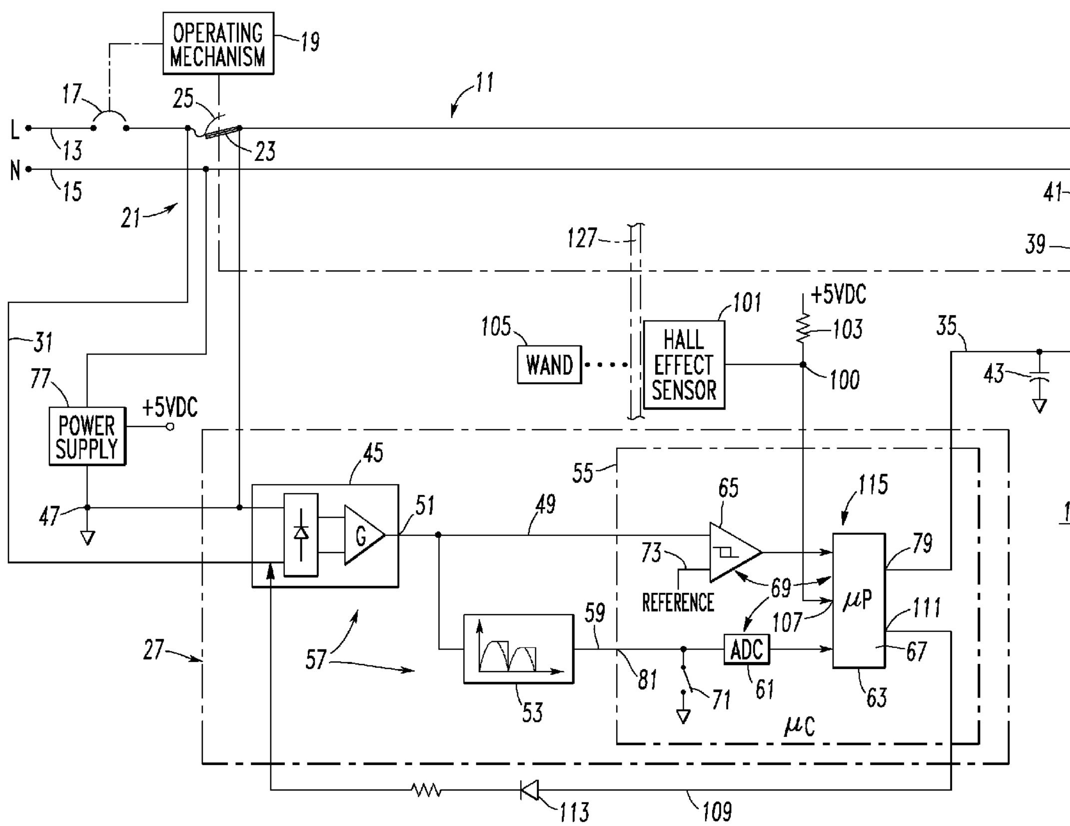
(57) **ABSTRACT**

An arc fault circuit breaker includes a panel having a first side and an opposite second side, a housing coupled to the opposite second side of the panel, separable contacts, an operating mechanism structured to open and close the separable contacts, and a trip mechanism cooperating with the operating mechanism to trip open the separable contacts. The trip mechanism includes a test circuit structured to simulate a trip condition to trip open the separable contacts, and a proximity sensor disposed on or within the housing proximate the opposite second side of the panel. The proximity sensor is structured to sense a target to actuate the test circuit when the target is disposed proximate the first side of the panel and opposite the proximity sensor.



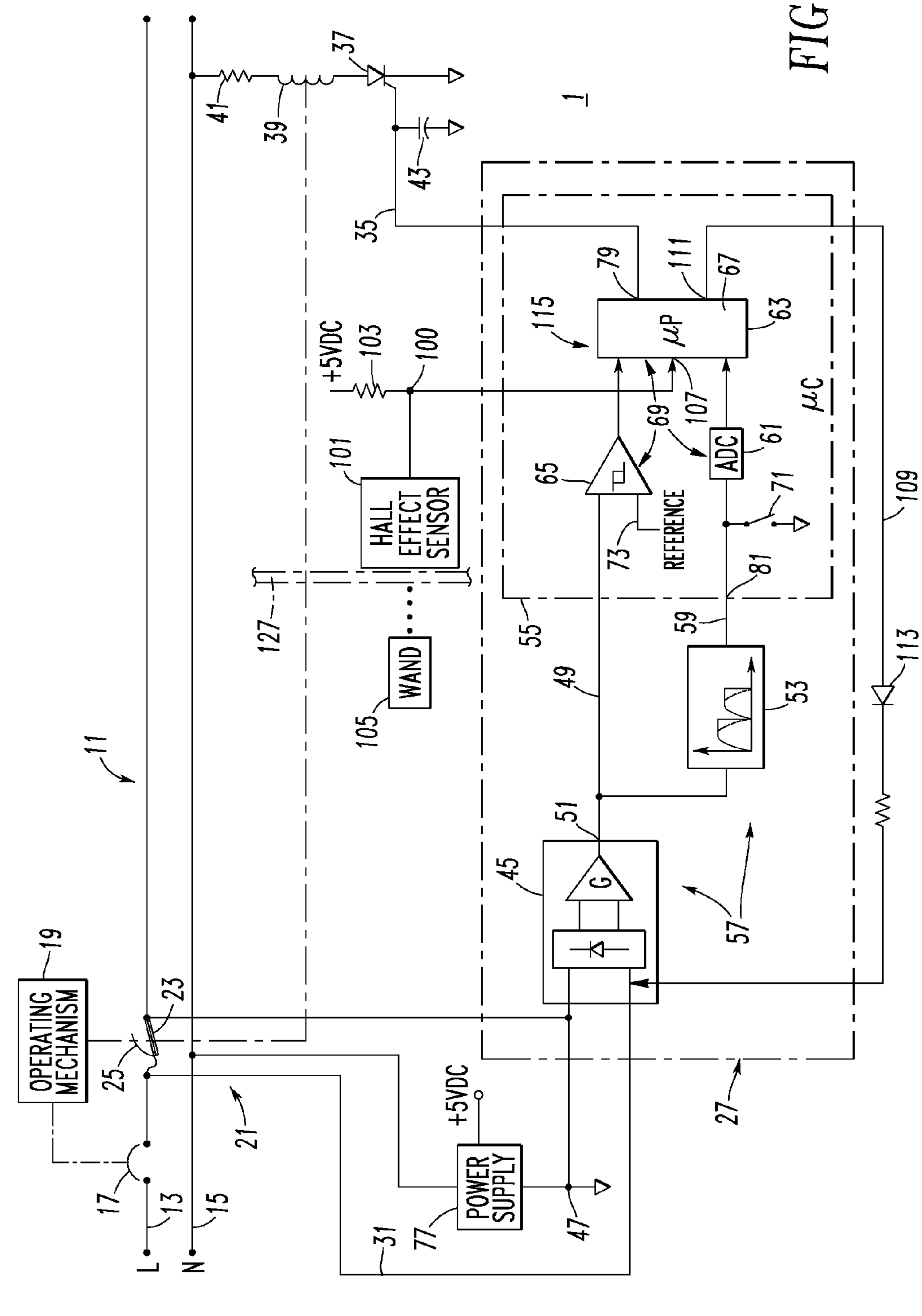

OPERATING MECHANISM
POWER SUPPLY
+5VDC
HALL EFFECT SENSOR
WAND
ADC
REFERENCE
μP
μC
G
L
N

FIG. 1

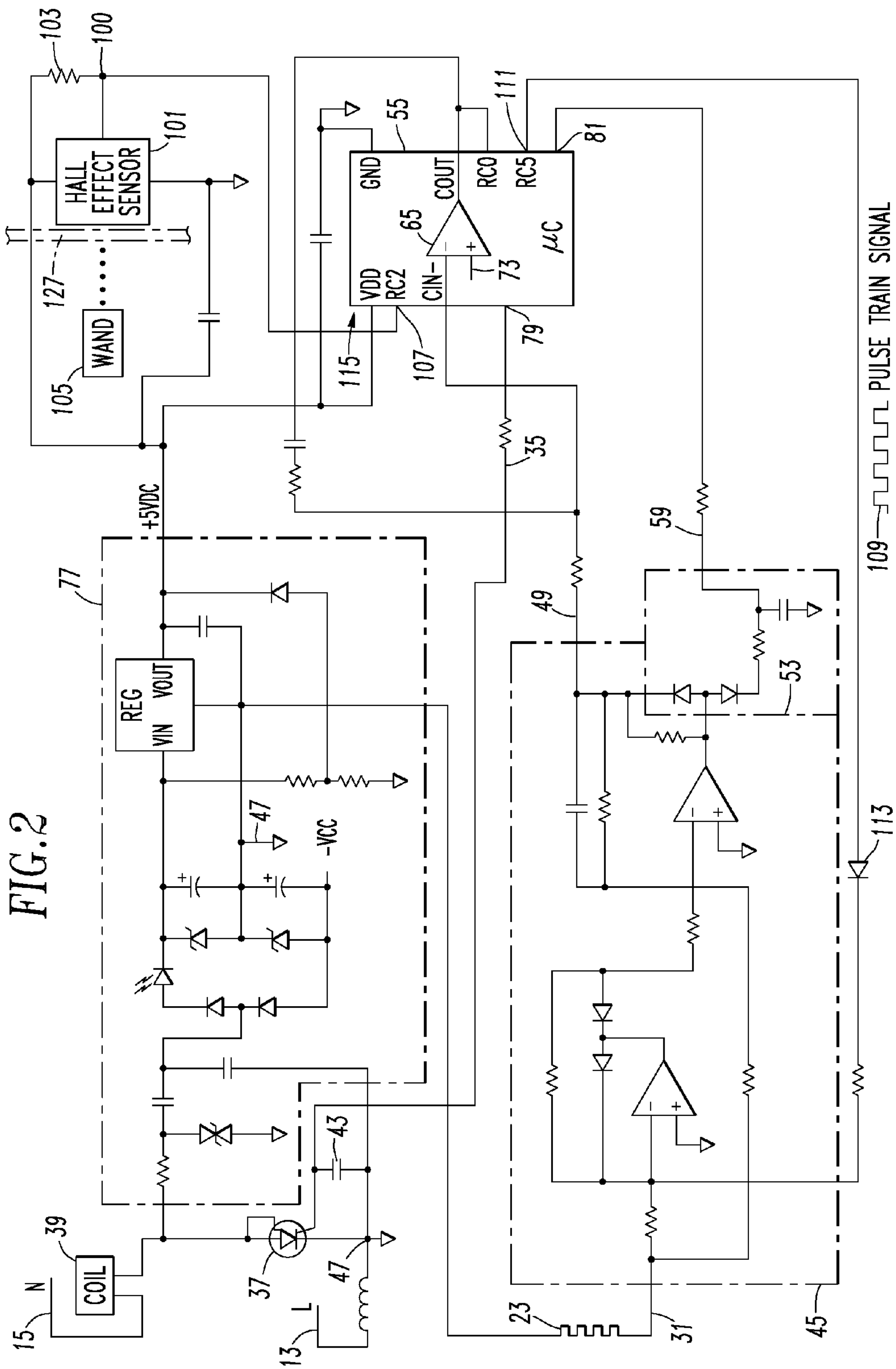

103
100
HALL EFFECT SENSOR
101
55
111
81
GND
COUT
RC0
RC5
65
VDD
RC2
CIN-
73
μC
127
WAND
105
115
107
79
35
PULSE TRAIN SIGNAL
109
59
+5VDC
77
49
53
REG
VIN
VOUT
47
-VCC
113
39
COIL
N
15
37
47
L
13
43
23
31
45

FIG. 2

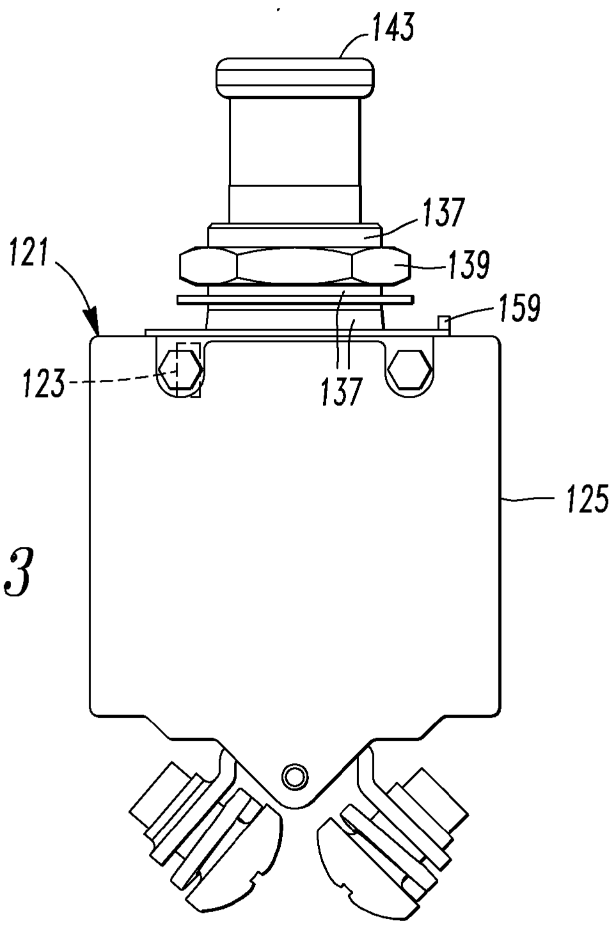


FIG. 3

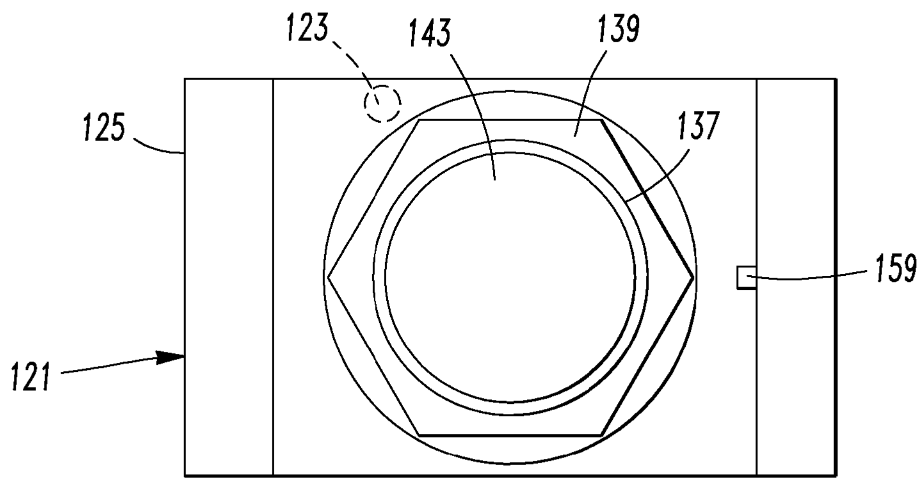


FIG. 4

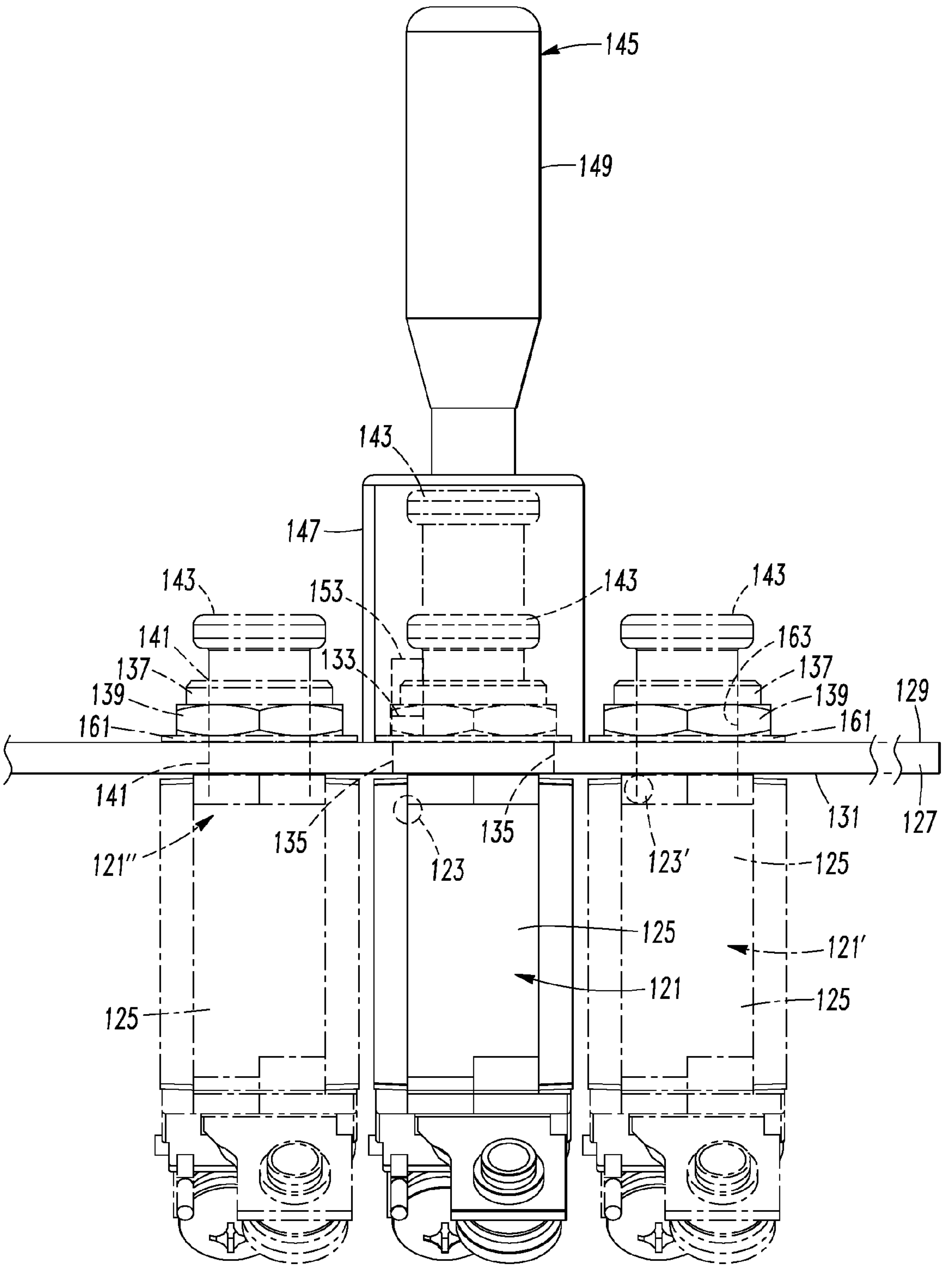

145
149
143
147
143
153
143
143
141
163
137
133
137
139
139
129
161
161
141
131
127
135
135
121''
123
123'
125
125
121'
121
125
125

FIG.5

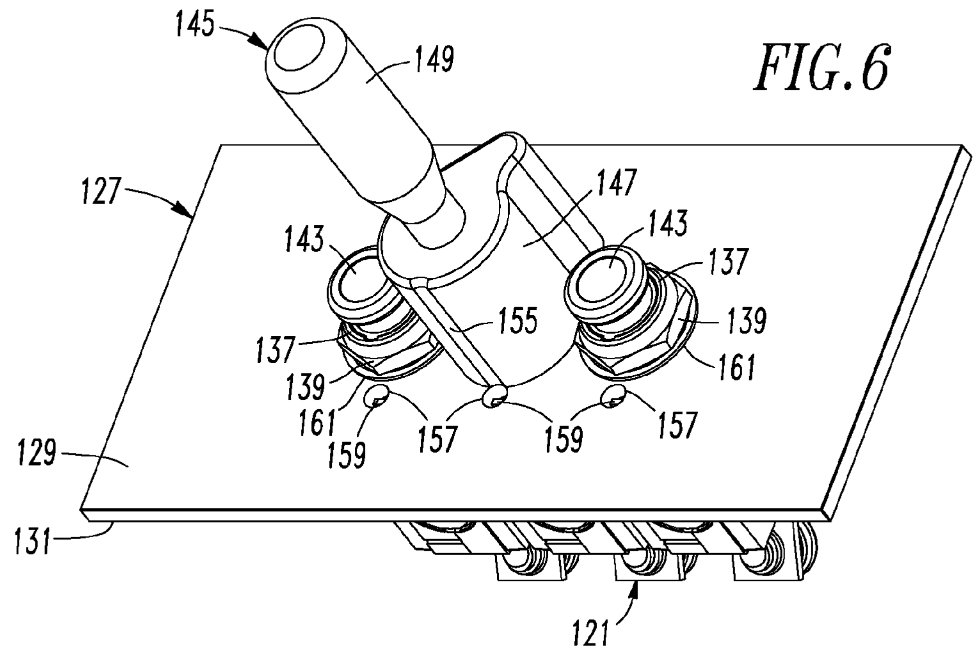

145
149
127
147
143
143
137
155
139
137
161
139
161
157
159
157
129
159
157
131
121

FIG. 6

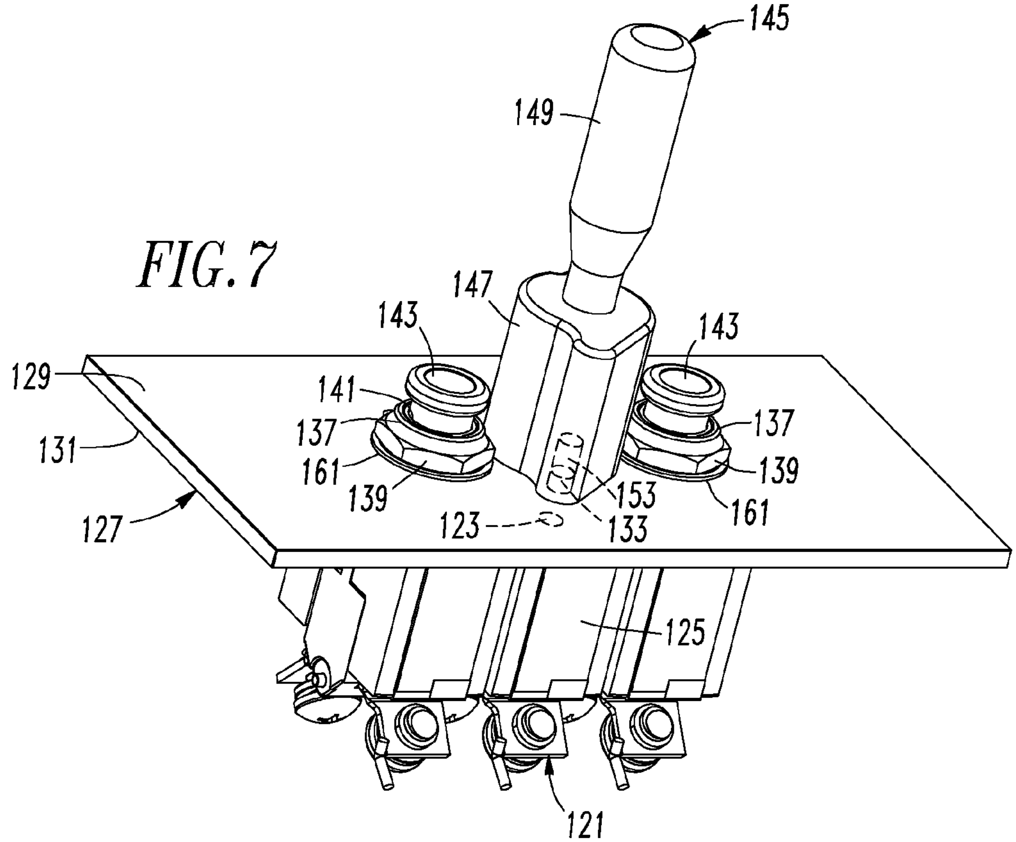

145
149
147
143
143
129
141
137
137
131
161
139
139
153
161
127
123
133
125
121

FIG. 7

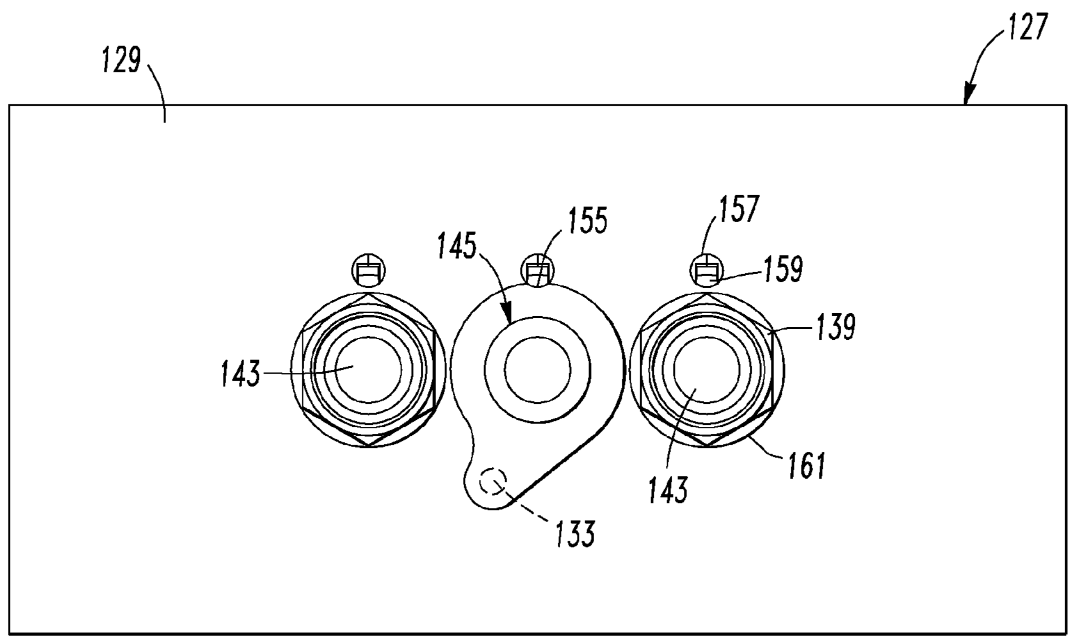


FIG. 8

METHOD OF ACTUATING A TEST FUNCTION OF AN ELECTRICAL SWITCHING APPARATUS AT A PANEL AND ELECTRICAL SWITCHING APPARATUS EMPLOYING THE SAME

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] This invention relates to electrical switching apparatus and, more particularly, to circuit interrupters, such as, for example, aircraft or aerospace circuit breakers providing arc fault protection. The invention also relates to methods of actuating a test function of an electrical switching apparatus, such as, for example, an arc fault test of an aircraft or aerospace circuit breaker.

[0003] 2. Background Information

[0004] Electrical switching apparatus include, for example, circuit switching devices; circuit interrupters, such as circuit breakers; network protectors; contactors; motor starters; motor controllers; and other load controllers.

[0005] Circuit breakers are used to protect electrical circuitry from damage due to an overcurrent condition, such as an overload condition or a relatively high level short circuit or fault condition. In small circuit breakers, commonly referred to as miniature circuit breakers, used for residential and light commercial applications, such protection is typically provided by a thermal-magnetic trip device. This trip device includes a bimetal, which heats and bends in response to a persistent overcurrent condition. The bimetal, in turn, unlatches a spring powered operating mechanism, which opens the separable contacts of the circuit breaker to interrupt current flow in the protected power system.

[0006] Subminiature circuit breakers are used, for example, in aircraft or aerospace electrical systems where they not only provide overcurrent protection but also serve as switches for turning equipment on and off. Such circuit breakers must be small to accommodate the high-density layout of circuit breaker panels, which make circuit breakers for numerous circuits accessible to a user. Aircraft electrical systems, for example, usually consist of hundreds of circuit breakers, each of which is used for a circuit protection function as well as a circuit disconnection function through a push-pull handle.

[0007] Typically, subminiature circuit breakers have provided protection against persistent overcurrents implemented by a latch triggered by a bimetal responsive to I^2R heating resulting from the overcurrent. There is a growing interest in providing additional protection, and most importantly arc fault protection.

[0008] During sporadic arc fault conditions, the overload capability of the circuit breaker will not function since the root-mean-squared (RMS) value of the fault current is too small to actuate the automatic trip circuit. The addition of electronic arc fault sensing to a circuit breaker can add one of the elements required for sputtering arc fault protection—ideally, the output of an electronic arc fault sensing circuit directly trips and, thus, opens the circuit breaker. See, for example, U.S. Pat. Nos. 6,710,688; 6,542,056; 6,522,509; 6,522,228; 5,691,869; and 5,224,006.

[0009] Common methods of actuating a test function on, for example, a circuit breaker, include employing a mechanical pushbutton switch. See, for example, U.S. Pat. Nos. 5,982,593; 5,459,630; 5,293,522; 5,260,676; and 4,081,852. However, such mechanical mechanisms often fail due to mechanical stress and may be actuated by mistake. Furthermore, such mechanical mechanisms, when employed on a relatively small circuit breaker, such as, for example, a subminiature circuit breaker, are of relatively large size.

[0010] Proximity sensors include, for example, Hall effect sensors. These sensors, used in automatic metal detectors, change their electrical characteristics when exposed to a magnet. Usually, such sensors have three wires for supply voltage, signal and ground.

[0011] Installation of arc fault circuit breakers in panels of aircraft (e.g., without limitation, optimized panels of F-15, F-16 or F-18 combat helicopters) provides little space to test such circuit breakers using an arc fault tester. When using the arc fault tester, the panel must be opened to access the rear terminals of the arc fault circuit breaker, the load connection to the arc fault circuit breaker must be disconnected, and the arc fault tester must be manually run.

[0012] U.S. Patent Application Publication No. 2006/0125582 discloses an aircraft or aerospace arc fault circuit breaker including a Hall effect sensor disposed within a housing and proximate a rear opening thereof. A target, such as a magnetic tool or magnetic wand, is inserted within the rear opening to actuate the Hall effect sensor. When the sensor changes state, this informs a processor that a test function has been initiated. The processor, then, responsively outputs a pulse stream signal that simulates an arcing event into the input stage of an arc fault detector, which trips the circuit breaker.

[0013] Aircraft or aerospace panels, which are typically dielectrically coated, obstruct testing from the rear of such panels when attempting to insert the magnetic target within the rear housing opening of the circuit breaker to actuate the Hall effect sensor. Hence, the panel must be removed to initiate the test function. However, test personnel must exercise extreme caution since the rear line and load terminals of the circuit breaker remain energized.

[0014] There is room for improvement in electrical switching apparatus employing a test function and in methods of actuating a test function of a panel-mounted electrical switching apparatus.

SUMMARY OF THE INVENTION

[0015] These needs and others are met by the invention, which actuates a test function of an electrical switching apparatus by disposing a target proximate the first side of a panel and opposite a proximity sensor, which is disposed on or within a housing of the electrical switching apparatus and proximate the opposite second side of the panel. Then, responsive to sensing the target, the test function of the electrical switching apparatus is actuated.

[0016] In accordance with one aspect of the invention, a method actuates a test function of a circuit interrupter including a housing, the circuit interrupter being coupled to a panel having a first side and an opposite second side. The method comprises: coupling the housing to the panel at the opposite second side thereof; disposing a proximity sensor on or within the housing and proximate the opposite second side of the panel; disposing a target proximate the first side of the panel and opposite the proximity sensor; sensing the target with the proximity sensor; and responsive to the sensing the target, actuating the test function of the circuit interrupter.

[0017] The method may comprise providing an opening passing from the first side to the opposite second side of the panel; disposing a protrusion from the housing; passing the protrusion from the opposite second side of the panel, through the opening of the panel, and beyond the first side of the panel; disposing the proximity sensor completely within the housing and proximate the protrusion of the housing; and disposing the target proximate the protrusion of the housing at the first side of the panel and opposite the proximity sensor.

[0018] The method may comprise providing an opening passing from the first side to the opposite second side of the panel; disposing a threaded coupling member from the housing; passing the threaded coupling member from the opposite second side of the panel, through the opening of the panel, and beyond the first side of the panel; and coupling the housing to the panel with a threaded fastener on the threaded coupling member at the first side of the panel.

[0019] The method may comprise providing an opening passing from the first side to the opposite second side of the panel; disposing a protrusion from the housing; passing the protrusion from the opposite second side of the panel, through the opening of the panel, and beyond the first side of the panel; including an operating member with the circuit interrupter; disposing the operating member partially within the protrusion of the housing and beyond the first side of the panel; holding the target with a holding member proximate the operating member; and substantially covering the operating member with the holding member.

[0020] As another aspect of the invention, an electrical switching apparatus comprises: a panel having a first side and an opposite second side; a housing coupled to the opposite second side of the panel; separable contacts; an operating mechanism structured to open and close the separable contacts; and a trip mechanism cooperating with the operating mechanism to trip open the separable contacts, the trip mechanism comprising: a test circuit structured to simulate a trip condition to trip open the separable contacts, and a proximity sensor disposed on or within the housing proximate the opposite second side of the panel, the proximity sensor being structured to sense a target member to actuate the test circuit when the target member is disposed proximate the first side of the panel and opposite the proximity sensor.

[0021] The panel may comprise an opening passing from the first side to the opposite second side of the panel; and the housing may comprise a first threaded coupling member disposed from the housing, the first threaded coupling member passing from the opposite second side of the panel, through the opening of the panel, and beyond the first side of the panel, and may further comprise a second threaded coupling member coupling the first threaded coupling member to the panel.

[0022] The panel may comprise an opening passing from the first side to the opposite second side of the panel; the housing may comprise a first coupling member passing from the opposite second side of the panel, through the opening of the panel, and beyond the first side of the panel, and may further comprise a second coupling member coupling the first coupling member to the panel, the first coupling member having an opening therethrough; the operating mechanism may comprise an operating handle passing through the opening of the coupling member; and the target member may comprise a first portion structured to substantially surround the operating handle and the coupling member at the first side of the panel, and a second portion carried by the first portion and being structured to be sensed by the proximity sensor.

[0023] The first portion of the target member may be an insulative portion; and the second portion of the target member may be a magnetic portion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] A full understanding of the invention can be gained from the following description of the preferred embodiments when read in conjunction with the accompanying drawings in which:

[0025] FIG. **1** is a block diagram of a circuit breaker including a Hall effect sensor to actuate an arc fault test function in accordance with embodiments of the invention.

[0026] FIG. **2** is a block diagram in schematic form of the processor, power supply, active rectifier and gain stage, peak detector and Hall effect sensor of FIG. **1**.

[0027] FIG. **3** is a vertical elevation view of an aircraft or aerospace circuit breaker including a Hall effect sensor in accordance with another embodiment of the invention.

[0028] FIG. **4** is a top plan view of the aircraft or aerospace circuit breaker of FIG. **3**.

[0029] FIG. **5** is a vertical elevation view of an aircraft or aerospace circuit breaker panel including three circuit breakers and a target holding member in accordance with another embodiment of the invention.

[0030] FIGS. **6** and **7** are isometric views of the aircraft or aerospace circuit breaker panel, three circuit breakers and target holding member of FIG. **5**.

[0031] FIG. **8** is a top plan view of the aircraft or aerospace circuit breaker panel, three circuit breakers and target holding member of FIG. **5**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0032] As employed herein, the term "number" shall mean one or an integer greater than one (i.e., a plurality).

[0033] As employed herein, the term "processor" means a programmable analog and/or digital device that can store, retrieve, and process data; a computer; a workstation; a personal computer; a microprocessor; a microcontroller; a microcomputer; a central processing unit; a mainframe computer; a mini-computer; a server; a networked processor; or any suitable processing device or apparatus.

[0034] As employed herein, the statement that two or more parts are "connected" or "coupled" together shall mean that the parts are joined together either directly or joined through one or more intermediate parts. Further, as employed herein, the statement that two or more parts are "attached" shall mean that the parts are joined together directly.

[0035] The invention is described in association with a panel-mounted aircraft or aerospace arc fault circuit breaker, although the invention is applicable to a wide range of electrical switching apparatus at a panel, such as, for example and without limitation, circuit interrupters structured to detect a wide range of faults, such as, for example, arc faults or ground faults in power circuits.

[0036] Referring to FIG. **1**, an arc fault circuit breaker **1** is connected in an electric power system **11** which has a line conductor (L) **13** and a neutral conductor (N) **15**. The circuit breaker **1** includes separable contacts **17** which are electrically connected in the line conductor **13**. The separable contacts **17** are opened and closed by an operating mechanism **19**. In addition to being operated manually by a handle (not shown) (but see the operating handle **143** of FIGS. **3-8**), the operating mechanism **19** can also be actuated to open the separable contacts **17** by a trip assembly **21**. This trip assembly **21** includes the conventional bimetal **23** which is heated by persistent overcurrents and bends to actuate the operating mechanism **19** to open the separable contacts **17**. An armature **25** in the trip assembly **21** is attracted by the large magnetic force generated by very high overcurrents to also actuate the operating mechanism **19** and provide an instantaneous trip function.

[0037] The circuit breaker **1** is also provided with an arc fault detector (AFD) **27**. The AFD **27** senses the current in the electrical system **11** by monitoring the voltage across the bimetal **23** through the lead **31** with respect to local ground reference **47**. If the AFD **27** detects an arc fault in the electric power system **11**, then a trip signal **35** is generated which turns on a switch such as the silicon controlled rectifier (SCR) **37** to energize a trip solenoid **39**. The trip solenoid **39** when energized actuates the operating mechanism **19** to open the separable contacts **17**. A resistor **41** in series with the coil of the solenoid **39** limits the coil current and a capacitor **43** protects the gate of the SCR **37** from voltage spikes and false tripping due to noise. Alternatively, the resistor **41** need not be employed.

[0038] The AFD **27** cooperates with the operating mechanism **19** to trip open the separable contacts **17** in response to an arc fault condition. The AFD **27** includes an active rectifier and gain stage **45**, which rectifies and suitably amplifies the voltage across the bimetal **23** through the lead **31** and the local ground reference **47**. The active rectifier and gain stage **45** outputs a rectified signal **49** on output **51** representative of the current in the bimetal **23**. The rectified signal **49** is input by a peak detector circuit **53** and a microcontroller (μC) **55**.

[0039] The active rectifier and gain stage **45** and the peak detector circuit **53** form a first circuit **57** structured to determine a peak amplitude **59** of a rectified alternating current pulse based upon the current flowing in the electric power system **11**. The peak amplitude **59** is stored by the peak detector circuit **53**.

[0040] The μC **55** includes an analog-to-digital converter (ADC) **61**, a microprocessor (μP) **63** and a comparator **65**. The μP **63** includes one or more arc fault algorithms **67**. The ADC **61** converts the analog peak amplitude **59** of the rectified alternating current pulse to a corresponding digital value for input by the μP **63**. The μP **63**, arc fault algorithm(s) **67** and ADC **61** form a second circuit **69** structured to determine whether the peak amplitude of the current pulse is greater than a predetermined magnitude. In turn, the algorithm(s) **67** responsively employ the peak amplitude to determine whether an arc fault condition exists in the electric power system **11**.

[0041] The μP **63** includes an output **71** structured to reset the peak detector circuit **59**. The second circuit **69** also includes the comparator **65** to determine a change of state (or a negative (i.e., negative-going) zero crossing) of the alternating current pulse of the current flowing in the electric power system **11** based upon the rectified signal **49** transitioning from above or below (or from above to below) a suitable reference **73** (e.g., a suitable positive value of slightly greater than zero). Responsive to this negative zero crossing, as determined by the comparator **65**, the μP **63** causes the ADC **61** to convert the peak amplitude **59** to a corresponding digital value.

[0042] The example arc fault detection method employed by the AFD **27** is "event-driven" in that it is inactive (e.g., dormant) until a current pulse occurs as detected by the comparator **65**. When such a current pulse occurs, the algorithm(s) **67** record the peak amplitude **59** of the current pulse as determined by the peak detector circuit **53** and the ADC **61**, along with the time since the last current pulse occurred as measured by a timer (not shown) associated with the μP **63**. The arc fault detection method then uses the algorithm(s) **67** to process the current amplitude and time information to determine whether a hazardous arc fault condition exists. Although an example AFD method and circuit are shown, the invention is applicable to a wide range of AFD methods and circuits. See, for example and without limitation, U.S. Pat. Nos. 6,710,688; 6,542,056; 6,522,509; 6,522,228; 5,691,869; and 5,224,006.

[0043] An output **100** of a suitable proximity sensor, such as, for example and without limitation, a Hall effect sensor **101**, is held "high" by a pull-up resistor **103**. When the Hall effect sensor **101** is actuated, for example, by a suitable target, such as for example and without limitation, a magnetic wand **105**, the sensor output **100** is driven low (e.g., by an open drain output). When the μP **63** determines that the input **107** is low, it outputs a suitable pulse train signal **109** on output **111**. That signal **109** is fed back into the input of the active rectifier and gain stage **45**. In turn, the pulse train signal **109** causes the AFD algorithms **67** to determine that there is an arc fault trip condition, albeit a test condition, such that the trip signal **35** is set. A blocking diode **113** is employed to prevent any current from flowing into the μP output **111**.

[0044] FIG. **2** is a block diagram in schematic form of the μC **55**, power supply **77**, active rectifier and gain stage **45**, peak detector **53** and Hall effect sensor **101** of FIG. **1**. The μC **55** may be, for example, a suitable processor, such as model PIC 16F676 marketed by Microchip Technology Inc. of Chandler, Ariz. A digital output **79** includes the trip signal **35**. An analog input **81** receives the peak amplitude **59** for the ADC **61** (FIG. **1**). Digital input RC**0** of μC **55** is employed to read the output (COUT) of the comparator **65**. Another digital input RC**2** **107** of μC **55** is employed to read the sensor output **100**. Another digital output RC**5** **111** of μC **55** includes the pulse train signal **109** to simulate an arc fault trip condition responsive to the sensing the magnetic wand **105** with the sensor **101**. The μC **55**, thus, forms an arc fault trip mechanism including a test circuit **115** structured to simulate an arc fault trip condition to trip open the separable contacts **17** (FIG. **1**).

[0045] FIGS. **3** and **4** show an aircraft or aerospace circuit breaker **121**, which may be the same as or similar to the circuit breaker **1** of FIG. **1**. A proximity sensor, such as the example Hall effect sensor **123** (shown in hidden line drawing), which may be the same as or similar to the sensor **101** of FIG. **1**, is disposed within a housing **125**.

[0046] Referring to FIGS. **5-8**, the aircraft or aerospace circuit breaker **121** is mounted on an aircraft or aerospace panel **127**. The example panel **127** has a first side **129** and an opposite second side **131**. The housing **125** is coupled to the opposite second side **131** of the panel **127**. The example Hall effect sensor **123** (shown in hidden line drawing in FIGS. **5** and **7**) is disposed within the housing **125** proximate the opposite second side **131** of the panel **127**. As will be discussed, the sensor **123** is structured to sense a target **133** (shown in hidden line drawing in FIGS. **5**, **7** and **8**) to actuate the test circuit **115** (FIGS. **1** and **2**) and the corresponding arc fault test function when the target **133** is disposed proximate the first side **129** of the panel **127** and opposite the sensor **123**.

[0047] Alternatively, in the aircraft or aerospace circuit breaker **121'**, which is similar to the circuit breaker **121**, the example Hall effect sensor **123'** (shown in hidden line drawing in FIG. **5**) is disposed on the surface of the housing **125** proximate the opposite second side **131** of the panel **127**.

[0048] As shown in FIG. **5**, the panel **127** includes an opening **135** (shown in hidden line drawing) passing from the first side **129** to the opposite second side **131** of the panel **127**. The housing **125** includes a protrusion, such as the example first threaded coupling member **137** (e.g., bezel) (also shown in FIG. **3**), disposed from the housing **125**. The coupling member **137** passes from the opposite second side **131** of the panel **127**, through the panel opening **135**, and beyond the first side **129** of the panel **127**. A second threaded coupling member, such as a threaded fastener, such as the example nut **139** (also shown in FIG. **3**) at the first side **129** of the panel **127**, couples the first threaded coupling member **137** to the panel **127**. This couples the housing **125** to the panel **127** at the opposite second side **131** thereof.

[0049] As best shown in FIGS. **5** and **7**, the first threaded coupling member **137** has an opening **141** (shown in hidden line drawing in FIG. **5**) therethrough. The operating mechanism **19** (FIG. **1**) includes an operating member, such as the example operating handle **143**, passing through the opening **141**. The operating handle **143** is disposed partially within the first threaded coupling member **137** and beyond the first side **129** of the panel **127**. A target member, such as a target holding member **145**, includes a first insulative portion **147** structured to substantially surround the operating handle **143** and the first threaded coupling member **137** at the first side **129** of the panel **127**, a second portion, which is the target **133** (shown in hidden line drawing), carried by the first insulative portion **147** and structured to be sensed by the sensor **123**, and a handle portion **149**. The example sensor **123** (shown in hidden line drawing) is disposed completely within the housing **125** and proximate the first threaded coupling member **137** thereof. The target **133** is proximate the first threaded coupling member **137** at the first side **129** of the panel **127** and opposite the sensor **123**.

[0050] As shown in FIGS. **5**, **7** and **8**, the target **133** is held by the first insulative portion **147** proximate the operating handle **143** (shown in hidden line drawing in a "closed" position of the circuit breaker **121** and shown in phantom line drawing in an "open" position of the circuit breaker **121**). The first insulative portion **147** preferably at least substantially covers the operating handle **143**. The first insulative portion **147** holds a magnetic inner second portion that is the target **133**.

[0051] In FIGS. **5-8**, the target holding member **145** and the target **133** are positioned to actuate the Hall effect sensor **123** of FIGS. **3-5** and **7**, in order to output the pulse train signal **109** of FIG. **2**. The target **133** is disposed within a cylindrical opening **153** (shown in hidden line drawing in FIGS. **5** and **7**) of the target holding member **145**.

[0052] As shown in FIGS. **6** and **8**, a user (not shown) mechanically aligns the target holding member **145**, which is guided by the bezel **137** and stops at the circuit breaker alignment tab **159** or, alternatively, visually aligns the target holding member **145** by using the notch **155** thereof and the panel opening **157** for the circuit breaker alignment tab **159** (best shown in FIG. **3**). Preferably, the target holding member **145** is dimensionally constrained by the circuit breaker alignment tab **159** and the bezel **137** to limit its rotational movement about the bezel **137**, thereby preventing the target **133** from actuating the sensor **123** of one of the two example adjacent circuit breakers **121'**,**121 "** in the position of FIG. **8**.

[0053] The panel **127** is preferably made of a non-ferrous material, such as aluminum or a suitable plastic. The sensor **123** and the target **133** are proximate (e.g., suitably near) the bezel **137**, which is preferably made of brass. The example magnetic target **133** changes the field direction of the example Hall effect sensor **123**, which actuates the arc fault test circuit **115**. The example steel nut **139**, steel washer **161** and the internal circuit breaker operating mechanism **19** (shown in block form in FIG. **1**) do not affect the sensor **123** since, for example, as was discussed above, a relatively extremely strong magnet, such as the example target **133**, is employed to actuate the example sensor **123**.

[0054] The opening **163** in the target holding member **145** can accommodate both the closed (shown in hidden line drawing in FIG. **5**) and open (shown in phantom line drawing in FIG. **5**) positions of the operating handle **143**. Alternatively, if the example circuit breaker **121** can trip independent of movement of the operating handle **143**, then the opening **163** in the target holding member **145** need only accommodate the closed (shown in hidden line drawing in FIG. **5**) position of the operating handle **143**.

[0055] The invention provides a relatively easy way to test the trip electronics to verify the reliability of the circuit breakers **1**,**121**,**121'**,**121"**. The target holding member **145** with the magnetic target **133** is positioned to actuate the Hall effect sensor **123** of FIGS. **3-5** and **7**, or the sensor **123'** of FIG. **5**. The concentrated magnetic field over the Hall effect sensors **101**,**123**,**123'** changes the state of the sensor output **100** (FIG. **1**), which is electrically connected to the input **107** of the processor **63**. When the sensor changes state, the input into the processor **63** changes, thereby informing such processor that the arc fault test function has been initiated. The processor **63**, then, responsively outputs the pulse stream signal **109** that simulates an arcing event into the input stage of the AFD **27** that trips the arc fault circuit breaker **1**.

[0056] Although a Hall effect digital sensor **101** is disclosed, any suitable proximity sensor may be employed. For example, an analog Hall effect sensor (not shown) may be employed, albeit with additional circuitry (not shown), in order to provide a suitable digital output, such as **100**. As a further alternative to analog Hall effect sensors, a suitable magneto-resistive device (not shown) or a NAMUR inductive proximity sensor (not shown) (e.g., marketed by Turck, Inc. of Minneapolis, Minn.; Pepperl & Fuchs of Twinsburg, Ohio) may also be employed. Alternatively, a wide range of inductive proximity sensors (not shown) may be employed.

[0057] Although an arc fault test function is disclosed, any suitable test function, such as, for example and without limitation, a ground fault test function or any other suitable test function of an electrical switching apparatus may be employed.

[0058] Although an example AFD **27** is shown, it will be appreciated that a combination of one or more of analog, digital and/or processor-based circuits may be employed.

[0059] The disclosed Hall effect sensors **101**,**123**,**123'** initiate a built-in test function of an electrical switching apparatus. These sensors reduce failure rate, improve reliability and employ a suitable tool, such as a magnetic wand **105** or target holding member **145**, to actuate the corresponding sensor and, thus, the corresponding test function.

[0060] Although separable contacts **17** are disclosed, suitable solid state separable contacts may be employed. For example, the disclosed circuit breaker **1** includes a suitable circuit interrupter mechanism, such as the separable contacts

17 that are opened and closed by the operating mechanism 19, although the invention is applicable to a wide range of circuit interruption mechanisms (e.g., without limitation, solid state or FET switches; contactor contacts) and/or solid state based control/protection devices (e.g., without limitation, drives; soft-starters).

[0061] While specific embodiments of the invention have been described in detail, it will be appreciated by those skilled in the art that various modifications and alternatives to those details could be developed in light of the overall teachings of the disclosure. Accordingly, the particular arrangements disclosed are meant to be illustrative only and not limiting as to the scope of the invention which is to be given the full breadth of the claims appended and any and all equivalents thereof.

What is claimed is:

1. A method of actuating a test function of a circuit interrupter including a housing, said circuit interrupter being coupled to a panel having a first side and an opposite second side, said method comprising:

coupling said housing to said panel at the opposite second side thereof;

disposing a proximity sensor on or within said housing and proximate the opposite second side of said panel;

disposing a target proximate the first side of said panel and opposite said proximity sensor;

sensing said target with said proximity sensor; and

responsive to said sensing said target, actuating said test function of said circuit interrupter.

2. The method of claim **1** further comprising

providing an opening passing from the first side to the opposite second side of said panel;

disposing a protrusion from said housing;

passing said protrusion from the opposite second side of said panel, through the opening of said panel, and beyond the first side of said panel;

disposing said proximity sensor completely within said housing and proximate the protrusion of said housing; and

disposing said target proximate the protrusion of said housing at the first side of said panel and opposite said proximity sensor.

3. The method of claim **2** further comprising

employing as the protrusion of said housing a bezel.

4. The method of claim **1** further comprising

providing an opening passing from the first side to the opposite second side of said panel;

disposing a threaded coupling member from said housing;

passing said threaded coupling member from the opposite second side of said panel, through the opening of said panel, and beyond the first side of said panel; and

coupling said housing to said panel with a threaded fastener on the threaded coupling member at the first side of said panel.

5. The method of claim **1** further comprising

providing an opening passing from the first side to the opposite second side of said panel;

disposing a protrusion from said housing;

passing said protrusion from the opposite second side of said panel, through the opening of said panel, and beyond the first side of said panel;

including an operating member with said circuit interrupter;

disposing said operating member partially within the protrusion of said housing and beyond the first side of said panel;

holding said target with a holding member proximate said operating member; and

substantially covering said operating member with said holding member.

6. The method of claim **1** further comprising

employing as said target a magnetic target.

7. The method of claim **1** further comprising

including an arc fault trip mechanism with said circuit interrupter; and

outputting a pulse train signal to simulate an arc fault trip condition responsive to said sensing said target with said proximity sensor.

8. The method of claim **1** further comprising

employing as said proximity sensor a Hall effect sensor.

9. The method of claim **1** further comprising

employing as said circuit interrupter a circuit breaker including separable contacts;

including with said circuit breaker a trip mechanism having a test circuit structured to simulate a trip condition to trip open said separable contacts; and

outputting a signal to simulate the trip condition and trip open said separable contacts responsive to said sensing said target with said proximity sensor.

10. The method of claim **9** further comprising

employing as said trip mechanism an arc fault trip mechanism; and

outputting a pulse train signal to simulate an arc fault trip condition responsive to said sensing said target with said proximity sensor.

11. An electrical switching apparatus comprising:

a panel having a first side and an opposite second side;

a housing coupled to the opposite second side of said panel;

separable contacts;

an operating mechanism structured to open and close said separable contacts; and

a trip mechanism cooperating with said operating mechanism to trip open said separable contacts, said trip mechanism comprising:

a test circuit structured to simulate a trip condition to trip open said separable contacts, and

a proximity sensor disposed on or within said housing proximate the opposite second side of said panel, said proximity sensor being structured to sense a target member to actuate said test circuit when said target member is disposed proximate the first side of said panel and opposite said proximity sensor.

12. The electrical switching apparatus of claim **11** wherein said panel comprises an opening passing from the first side to the opposite second side of said panel; and wherein said housing comprises a first threaded coupling member disposed from said housing, said first threaded coupling member passing from the opposite second side of said panel, through the opening of said panel, and beyond the first side of said panel, and further comprises a second threaded coupling member coupling said first threaded coupling member to said panel.

13. The electrical switching apparatus of claim **11** wherein said panel comprises an opening passing from the first side to the opposite second side of said panel; wherein said housing comprises a first coupling member passing from the opposite second side of said panel, through the opening of said panel, and beyond the first side of said panel, and further comprises a second coupling member coupling said first coupling member to said panel, said first coupling member having an opening therethrough; wherein said operating mechanism comprises an operating handle passing through the opening of said coupling member; and wherein said target member comprises a first portion structured to substantially surround said operating handle and said coupling member at the first side of said panel, and a second portion carried by said first portion and being structured to be sensed by said proximity sensor.

14. The electrical switching apparatus of claim **13** wherein the first portion of said target member is an insulative portion; and wherein the second portion of said target member is a magnetic portion.

15. The electrical switching apparatus of claim **11** wherein said trip mechanism is an arc fault trip mechanism; and wherein said test circuit is structured to output a pulse train signal to simulate an arc fault trip condition to trip open said separable contacts.

16. The electrical switching apparatus of claim **11** wherein said proximity sensor is a Hall effect sensor.

17. The electrical switching apparatus of claim **11** wherein said target member includes a magnetic target.

18. The electrical switching apparatus of claim **11** wherein said proximity sensor comprises an output which is actuated when said target member is sensed; and wherein said test circuit comprises a processor having an input receiving the output of said proximity sensor.

19. The electrical switching apparatus of claim **18** wherein said processor further has an output, which is actuated responsive to the input of said processor receiving the actuated output of said proximity sensor.

20. The electrical switching apparatus of claim **19** wherein the output of said processor outputs a signal to simulate a trip condition to trip open said separable contacts responsive said proximity sensor sensing said target member.

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